Model PRM-7 | Micro R/h Meter Technical Manual

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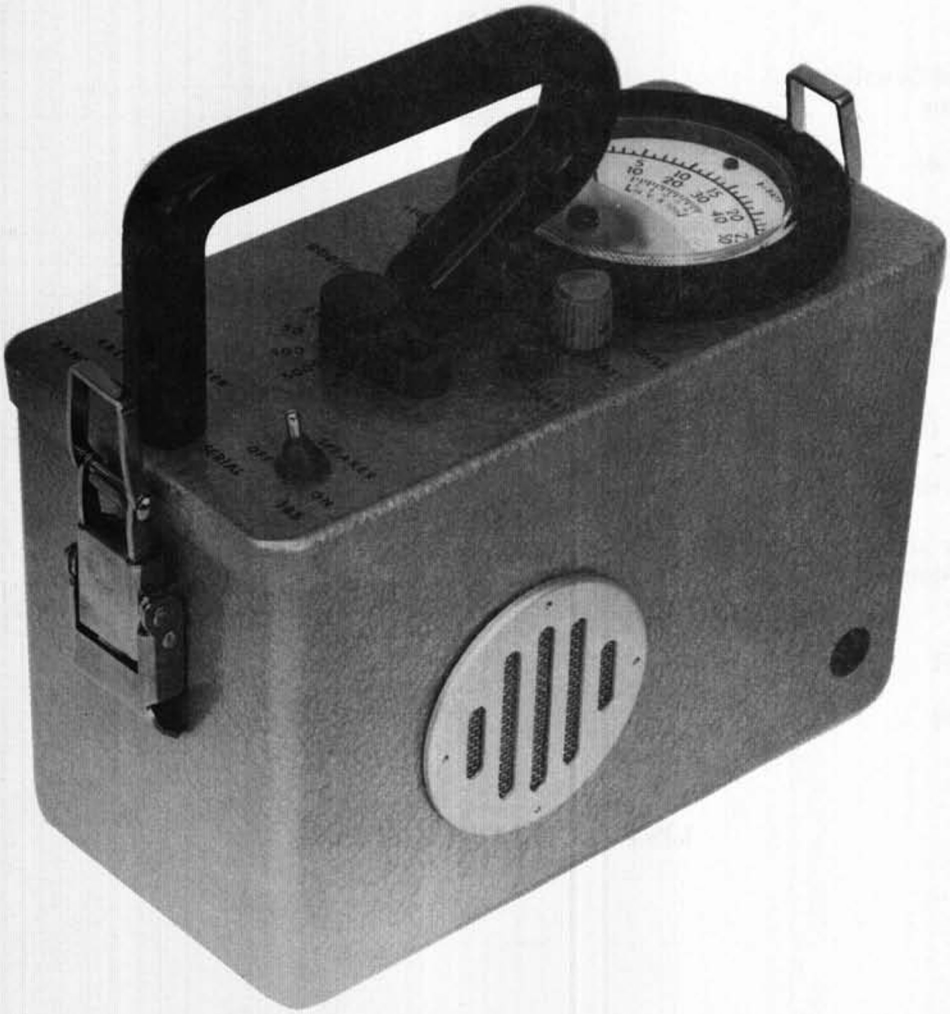


Figure 1-1. Model PRM-7, Micro R/hr Meter

SECTION I
GENERAL

A. PURPOSE AND DESCRIPTION

The Model PRM-7 Micro R/hr Meter is a special purpose survey meter used to measure background radiation levels and to locate and measure sources of radiation that cause the background readings to change. The PRM-7 incorporates an internal scintillation detector which is sensitive to gamma radiations.

Extensive use of integrated circuits, variable high voltage with readout of setting on the meter, two D-cell operation, and rugged construction are among its design features.

The single range switch with BATTery check and high voltage readout positions and easy to read meter scale enhance ease of operation.

B. SPECIFICATIONS

1. Readout

a. Meter: Ruggedized with 0-25 and 0-50 scales, BATTery OK limits, and High Voltage scale. Micro R/hr scale length is 2.38 inches (6 cm).

b. Range: Switch controlled 0-25, 0-50, 0-500, 0-5000 micro R/hr, referenced to ^{137}Cs.

NOTE

The PRM-7 response is energy dependent. It is calibrated to ^{137}Cs at the factory.

c. Linearity: Within ±5% of full scale (±2% typical) when driven with a repetitive signal.

d. Response Time: Continuously variable by a front panel control from approximately 10 seconds to 2 seconds measured to 90% of final meter reading.

e. Speaker: 2 inch diameter internal to instrument. On-off switch provided.

f. Meter Lamp: Handle mounted, push button controlled.

g. Voltage Coefficient: Meter reading changes less than 2% with battery voltage from 2.2 to 3.1 V.

2. Detector

a. Scintillation detector with 1-inch diameter x 1 inch length sodium iodide crystal. A one-inch diameter end window photomultiplier tube with a S-11 response is used.

3. Low Voltage Power Supply

a. Batteries: Two D-cells held by internal captive holders.

b. Voltage Requirement: 1.6 maximum to 1.1 minimum volts per cell.

c. Life: Variable depending on cell type, age, temperature, high voltage setting, meter lamp usage, etc. Typical life with new cells at room temperature (meter light off) is:

C-Zn cells	225 hours
Alkaline	270 hours
Mercury	450 hours
NiCd (single charge)	135 hours

4. High Voltage Supply

a. Range: Variable by internal control from less than 500 V to more than 1200 V.

b. Readout: High voltage can be read out on the meter. Readout is selected on the range switch. Accuracy of reading is ±10%.

c. Voltage Dependence: High voltage will change less than ±3% with battery voltage from 2.2 to 3.1 V.

5. Environmental

The instrument is operational from 0°F to +140°F (-18°C to +60°C). The battery type used limits the low temperature performance because of terminal voltage decrease and internal impedance increase. For prolonged operation at low temperatures, the following low limits are suggested: Mercury, +32°F (0°C); C Zn, Alkaline or NiCd, 0°F (-18°C).

6. Mechanical

a. Dimensions: Approximately 4 inches wide x 8 inches long x 7-1/2 inches high including handle (10.2 x 20.3 x 19 cm).

b. Weight: Approximately 4 pounds 10 ounces (2.1 kg) including C-Zn batteries.

SECTION II

OPERATION

A. DESCRIPTION OF CONTROLS AND CONNECTORS

1. External (see Figure 1-1)

a. Switch: Seven-position rotary switch that turns the instrument OFF, checks BATTery condition, reads out high voltage and selects scales of 25, 50, 500 or 5k μR/hr.

b. Response: Controls response time of meter to the most desirable compromise between speed and fluctuation for a particular usage.

c. Reset: Discharges integrating capacitor, bringing the meter reading to zero rapidly.

d. Light Switch: Push button that lights meter lamp while button is depressed.

e. Speaker On-Off: Switch to control speaker.

2. Internal (see Figure 2-1)

a. Calibration Controls: One control for each range which individually calibrates the meter reading on that range to agree with the dose rate.

b. High Voltage Adjust: Controls magnitude of high voltage applied to the detector. Clockwise rotation increases voltage. Meter reading indicates magnitude when selected on the switch.

c. Detector Connector: BNC series.

B. PREPARATION FOR USE

The instrument should be checked for obvious physical damage.

C. USING THE INSTRUMENT

1. Starting

a. Turn the switch to the BATTery check position. The meter should indicate above the BATT mark. Press meter light switch. If meter drops below BATT mark, install new batteries if light is to be used during operation.

b. Turn the switch to the HV position. The meter should indicate the high voltage applied to the detector.

2. Operation Check

Place a check source (if available) in a repeatable position adjacent to the detector and move the switch to a range that gives an upscale reading. Note that the reading is sensitive to the position of the sources. The reading may be recorded for future reference.

If no check source is available, the normal background reading may be used as a check.

Push the RESET button and reading should drop to zero rapidly, then climb back to source reading when the RESET is released. The RESPONSE control may be set to get the most desirable compromise between speed of response and meter fluctuation.

3. Interpretation of Indications

The range switch indicates the full scale reading of range selected. The fluctuation of the meter is normal and is caused by the random nature of radioactive decay.

4. The speaker may be used as desired to give immediate indication of a change in count rate.

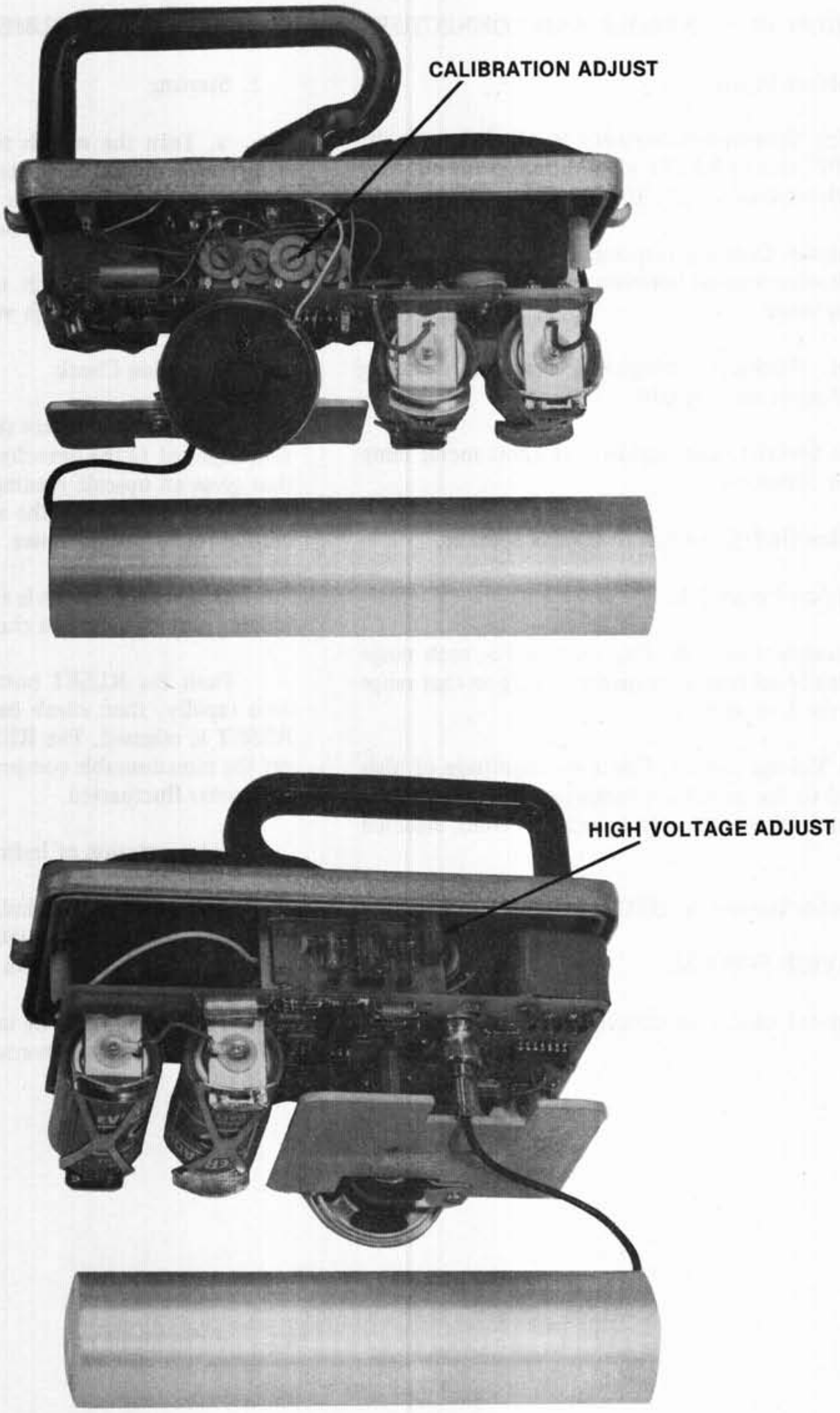


Figure 2-1. Pulse Rate Meter, Model PRM-7, Internal

SECTION III
THEORY OF OPERATION

A. GENERAL

The high voltage supply develops the voltage supplied to the photomultiplier tube. When radiation reacts in the crystal, a negative pulse is generated in the tube. These pulses are coupled into the amplifier and amplified. They are then coupled into the triggers.

Trigger #1 converts the pulses to standard shaped voltage pulses. These standard pulses are applied to the meter driver which converts them to standard pulses of current, averages this current and drives the meter. Thus, the meter deflection is proportional to the average rate of radiation at the detector.

Trigger #2 converts the pulses to a width that gives optimum sound from the speaker. The signal rate to the speaker is divided by 16 because of the high counting rate of the scintillator.

B. FUNCTIONAL THEORY (see Figure 3-1 and 6-1)

1. High Voltage Supply

The oscillator transistor Q10 drives the transformer primary and gets its feedback from the orange-red winding. The voltage is stepped up by the transformer secondary and voltage tripler circuit in the 10417-C01 assembly.

The voltage at the violet lead is divided by R35 through R39 and R40 through R42, so the voltage on the base of Q14 is proportional to the high voltage. This high voltage appears on the control side of a differential amplifier (Q13 and Q14), with the reference side tied to the high voltage adjust pot that is connected to the stable 1.2 V supply. If the two bases (Q13 and Q14) are not equal, the difference will be amplified (Q11 and Q12) and will change the level of the oscillator which changes the high voltage until they are equal.

Transistors Q15, Q16 and Q17 (part of A4) are connected as a current source for the differential amplifier. They are referenced to a negative voltage developed by the transformer primary, rectified by CR4, and filtered by C13.

When the selector switch (S1) is in the HV position, R42 is replaced by the meter which reads the current in the reference string and is displayed on the meter as high voltage.

2. Amplifier

Transistors Q1 and Q2 form a feedback-controlled preamplifier which amplifies the negative pulses from the detector. The feedback enhances stability, and biasing on Q1 protects from overdrive. Q3 is biased close to cut-off so its output is near 0 volts. A pulse turns it on and the resulting positive output pulse starts the trigger circuits.

Transistors Q1 and Q2 are part of integrated circuit A1.

3. Triggers

Integrated circuit A2 is a quad 2 input gate connected to operate as two individual monostable multivibrators. Trigger #1 (pins 5 through 10) controls the pulse width for the ratemeter circuit. Trigger #2 (pins 1 - 3 and 12 - 14) controls the pulse width for the speaker circuit.

a. Trigger #1: The pulse width is controlled by the RC time constant between its pins 7 and 8. This time constant is established by the setting of S1 (scale selection) which selects a particular R and C. The calibration controls form the R for each scale, making the pulse width continuously variable for calibration.

When the trigger is initiated by the pulse from Q3, the output (pin 5) goes positive and holds until the predetermined time (RC) elapses.

b. Trigger #2: The pulse width is controlled by the RC time constant (R20 and C10) between pins 14 and 1. This pulse width is fixed for an optimum duty cycle and sound from the speaker.

When the trigger is initiated the output (pin 3) goes positive and holds until the RC time elapses.

4. Signal Divider

The signal rate to the speaker is reduced by a factor of 16 to make the audible signal more usable. The signal from Q3 is routed through A5, a 14 stage binary counter, and the output of the fourth stage at pin 7 is used to drive the speaker trigger. Q20 is used to drive the counter and Q21 receives the counter signal and drives the trigger. The negative voltage generated by the high voltage power supply is used to increase the voltage across A5 (R55 and R53).

5. Meter Driver

The driver transistor Q5 is normally off, so no current flows through M1. When the trigger is on, Q4 turns on and also turns on Q5, so current flows through M1. The amount of current is determined by the voltage across R18. The length of time that current flows is determined by the pulse width

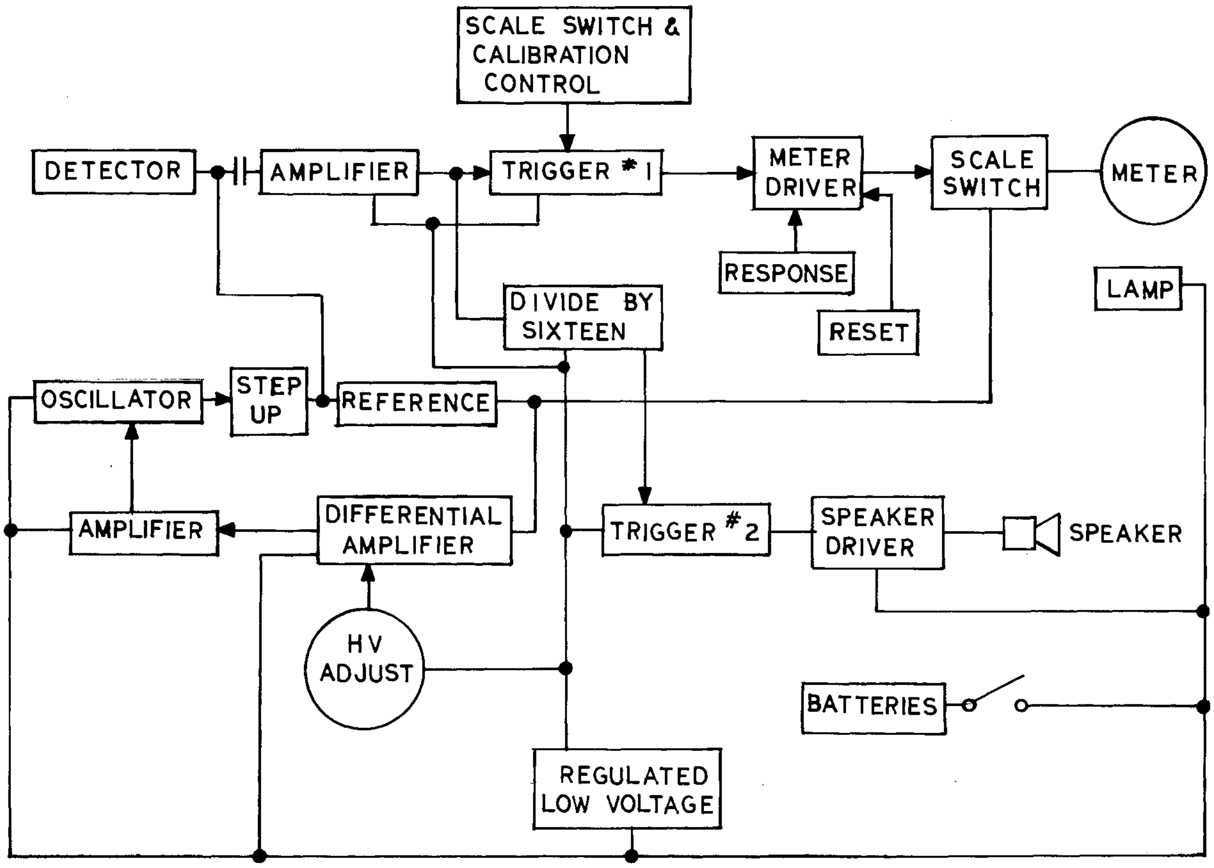


Figure 3-1. System Block Diagram

of the trigger. This (current times time) forms a certain charge which is transferred to C9 for each event counted. C9 discharges through M1, yielding a certain average current dependent on the rate of input pulses. Changing the pulse width of the trigger (i.e., changing scales or calibration pot setting) changes the average current for a given input pulse rate. This allows the meter to be calibrated to read in micro R/hr at the detector.

The response of M1 is controlled by the RC time constant of C9 and R19, the RESPONSE control. With R19 set to a low resistance, the time constant is fast, and at a high resistance, is slow.

To make the meter reading independent of battery voltage, Q4 is operated as a current source. Diode CR2 compensates the meter driver for temperature variations.

Transistor Q4 is part of integrated circuit A1.

6. Speaker Driver

Transistor Q6 inverts the pulse from Trigger #2 and provides the base drive for Q7 which drives the speaker output. Diode CR3 clips the inductive kick of the speaker.

SECTION IV
MAINTENANCE

A. DISASSEMBLY AND REASSEMBLY

1. Batteries: The batteries are secured in captive holders on the etched board. The holding straps may be removed by hand, but a small screwdriver facilitates removal. Pull the batteries from the holder. Replace by sliding batteries into holders, making certain they are centered and of the correct polarity. Replace holding straps.

2. Etched Board: The etched board and cover may be separated for troubleshooting. Proceed as follows:

   a. Disconnect the detector cable connector.

   b. Remove batteries to prevent electrical damage during disassembly.

   c. Remove knob and mounting nut from scale switch.

   d. Remove two screws that secure meter to circuit board.

   e. Separate board and cover without putting undue stress on wires.

   f. For troubleshooting, place jumpers from meter studs to corresponding points on board and replace batteries.

   g. Reassemble in reverse order of disassembly.

3. Meter Lamp: To replace the handle-mounted meter lamp, separate the etched circuit board from the cover as in 2 above. Unsolder the lamp wires coming from the handle at the switch and the ground lug. Grasp the old bulb with sticky tape and pull the lamp and wires out of the handle. (If this proves difficult, break the glass and grasp the filament or bulb base with needle nose pliers.) Insert the new lamp assembly (Eberline No. 10781-A44) and guide the wires out of the handle base. Push the bulb into the handle gently but firmly. Solder the lamp wires to the lamp switch and ground lug and reassemble the instrument.

4. Detector: The detector assembly is held in compressed foam material in the bottom of the instrument can. The foam is held in place by the batteries and a flat aluminum plate installed to hold the speaker. The detector may be removed by lifting out the foam padding.

To remove the crystal, phototube and socket network, remove the snap ring from the aluminum housing and pull gently on the plastic end piece. When re-installing, put a layer of clear silicone grease between the crystal and phototube to provide a light coupling.

B. PREVENTIVE MAINTENANCE

1. Keep the instrument clean and dry.

2. Replace batteries when their check reading is below the acceptable level.

3. Remove batteries if the instrument is to be inactive for a long period.

C. CALIBRATION

1. High Voltage Adjustment (See Figure 4-1).

The proper setting for the high voltage is to operate at about the midpoint of the detector plateau. This setting is best determined as follows:

Plot a plateau (μR/hr vs high voltage) with the detector counting the type of radiation of interest. For a fixed field, the meter reading will be low when a low "high" voltage setting is applied. The meter reading will increase as the high voltage increases until the plateau is reached. On the plateau the reading will increase slowly as high voltage is increased. When the noise threshold is reached, the meter reading will again increase quickly for increase in high voltage. This is the far end of the plateau. The operating point should be about in the middle of the plateau.

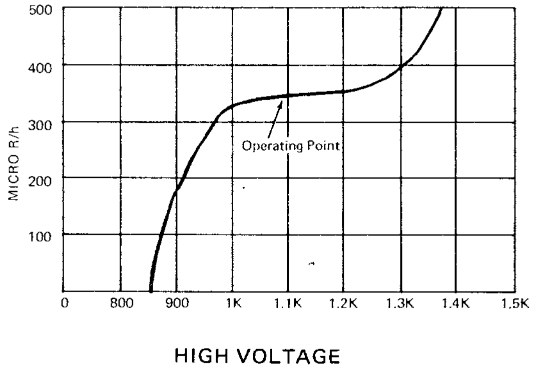


Figure 4-1. Typical Plateau, Model PRM-7

2. Ratemeter: The PRM-7 is calibrated so that the meter reads the field intensity in μR/hr, reference to ^{137}Cs.

For the higher two ranges, place the detector in a ^{137}Cs field that is equivalent to about 3/4 full scale of the range being calibrated. (Establish free air conditions as much as possible. The presence of massive materials, human bodies, etc., in the gamma field will cause scattering and will affect the meter reading.) Adjust the appropriate calibration control until the meter reads properly.

The two lower ranges can be calibrated in the same way as for the higher ones provided an accurate, very low intensity field can be established, considering the background contribution, etc.

A much quicker, simpler and better method involves the use of a signal generator such as the Eberline Model MP-1. After the upper two ranges have been calibrated, connect the MP-1 to the detector connector and set the PRM-7 range switch to the 500 position. Adjust the MP-1 for a PRM-7 meter reading in the upper half of the scale. Note the reading and the MP-1 frequency. Reduce the MP-1 frequency by a factor of ten and set the PRM-7 range switch to 50. Adjust the appropriate calibration control until the meter reads at the same point as before. Then reduce the MP-1 frequency by a factor of two and set the PRM-7 range switch to 25. Adjust the proper calibration control until the meter reads at the same point as before. This completes the calibration.

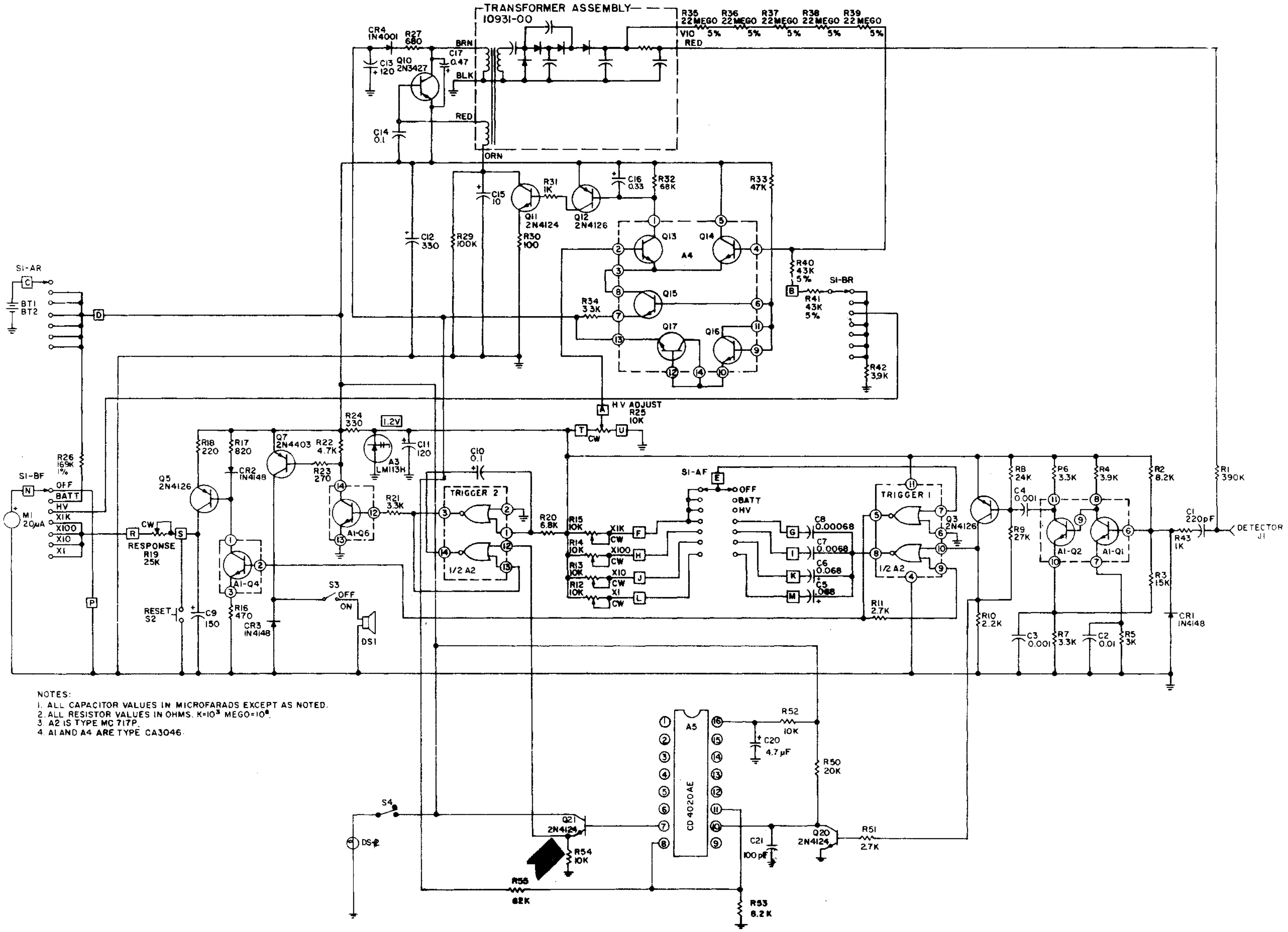
SECTION V
PARTS LIST

The following table lists the electronic items incorporated in the PRM-7 and should contain any part necessary for normal electronic repair. Unless otherwise specified, callouts of manufacturers and manufacturers' part numbers are to be considered typical examples only. There are no restrictions against using equivalent parts with the same operating characteristics. When ordering parts from Eberline, specify model number, serial number, reference designation, value, Eberline part number, or a word description if the part has no reference designation. Eberline will automatically substitute equivalent parts when the one called out by the manufacturers' part number is not available.

REF DESIG	PART	DESCRIPTION	MANUFACTURER AND PART NUMBER	EBERLINE PART NUMBER
1. Cover				
DS2	Lamp Assembly		Eberline 10781-A44	LPLP4 modified per 10781-A44
M1	Meter Meter Face	20 μA dc	Eberline 10781-B19	MTPA7 ZP10472115
R19	Potentiometer	Response, 25k, Linear	CTS Series 300 or Equivalent	PTCC253B23
S2, S4	Switch	Reset and Light	Grayhill No. 30-1	SWPB5
S3	Switch	SPST, Speaker *ON-OFF*	Alco MTA-106D	SWTO12
2. Electronics Board				
A1, A4	Integrated Circuit	Transistor Array	RCA-CA3046	ICRTACA3046
A2	Integrated Circuit	Quad 2-Input Gate	MOT MC-717P or Better	ICRTA0817P
A3	Integrated Circuit	Voltage Reference	National LM 113H	ICAVC0113H
BT1, BT2	Battery	"D" Cell, C-Zn		BTCZ3
C1	Capacitor	220 pF, 3 kV, 10%	CRL No. DD-30-221	CPCE221P3Y
C2	Capacitor	0.01, 80 V	Sprague 192P1039R8	CPPF103P3O
C3, C4	Capacitor	0.001, 200 V	Sprague 192P10292	CPPF102P3R
C5, C6	Capacitor	0.068, 35 V, 10%	CS13 Case A	CPTA683P3L
C7	Capacitor	0.0068, 80 V	Sprague 192P6829R8	CPPF682P3O
C8	Capacitor	0.00068, 200 V	Sprague 192P68192	CPPF681P3R
C9	Capacitor	150 μF, 6 V, 10%	CS13 Case C	CPTA151M3D
C10	Capacitor	0.1 μF, 35 V, 10%	CS13 Case A	CPTA104P3L
C11	Capacitor	120 μF, 10 V, 10%	CS13 Case C	CPTA121M3F
C12	Capacitor	330 μF, 6 V, 10%	CS13 Case C	CPTA331M3D
C13	Capacitor	120 μF, 15 V, 10%	CS13 Case D	CPTA121M3H
C14	Capacitor	0.1, 80 V	Sprague 192P1049R8	CPPF104P3O
C15	Capacitor	10 μF, 10 V	Components, Inc., Type CCM	CPTA100M3F
C16	Capacitor	3.3 μF, 35 V, 10%	CS13 Case A	CPTA334P3L
C17	Capacitor	0.47 μF, 35 V, 10%	CS13 Case A	CPTA474P3L

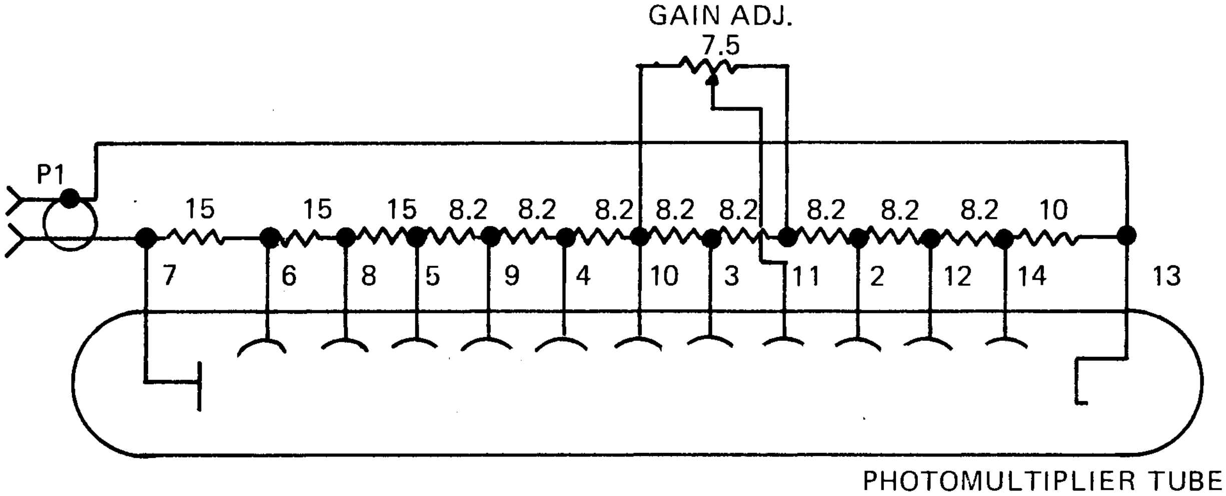
REF DESIG	PART	DESCRIPTION	MANUFACTURER AND PART NUMBER	EBERLINE PART NUMBER
CR1, CR2, CR3	Diode		1N4148	CRSI1N4148
CR4	Diode		1N4001	CRSI1N4001
DS1		Speaker, 2-inch diameter 8 Ω, 0.1 W	Lafayette No. SK-189 or Olsen No. S-433	ADSP3
J1	Connector	BNC	UG1094/U	CXBN8
Q3, Q5, Q12	Transistor		2N4126	TRSP2N4126
Q7	Transistor		2N4403	TRSP2N4403
Q10	Transistor		2N3427 or 2N3428	TRGP2N3427
Q11	Transistor		2N4124	TRSN2N4124
R1	Resistor	390k, 1/4 W, 10%		RECC394B22
R2	Resistor	8.2k, 1/4 W, 10%		RECC822B22
R3	Resistor	15k, 1/4 W, 10%		RECC153B22
R4, R42	Resistor	3.9k, 1/4 W, 10%		RECC392B22
R5	Resistor	3k, 1/4 W, 5%		RECC302B22
R6, R7, R21	Resistor	3.3k, 1/4 W, 10%		RECC332B22
R8	Resistor	24k, 1/4 W, 5%		RECC243B22
R9	Resistor	27k, 1/4 W, 10%		RECC273B22
R10	Resistor	2.2k, 1/4 W, 10%		RECC222B22
R11	Resistor	2.7k, 1/4 W, 10%		RECC272B22
R12, R13, R14, R15	Potentiometer	10k (Cal)	CTS Type XHT2014103B No. RR9167 (Preferred) or Mallory MCT	PTCC103B02
R16	Resistor	470 Ω, 1/4 W, 10%		RECC471B22
R17	Resistor	820 Ω, 1/4 W, 10%		RECC821B22
R18	Resistor	220 Ω, 1/4 W, 10%		RECC220B22
R20	Resistor	6.8k, 1/4 W, 10%		RECC682B22
R22	Resistor	4.7k, 1/4 W, 10%		RECC472B22
R23	Resistor	270 Ω, 1/4, 10%		RECC271B22
R24	Resistor	330, 1/4 W, 10%		RECC331B22
R26	Resistor	169k 1/4 W, 1%	IRC CEA-TO or equivalent	REMF164B11
R27	Resistor	680 Ω, 1/4 W, 10%		RECC681B22
R29	Resistor	100k, 1/4 W, 10%		RECC104B22
R30	Resistor	100 Ω, 1/4 W, 10%		RECC101B22
R31, R43	Resistor	1k, 1/4 W, 10%		RECC102B22
R32	Resistor	68k, 1/4 W, 10%		RECC683B22
R33	Resistor	47k, 1/4 W, 10%		RECC473B22
R34	Resistor	33k, 1/4 W, 10%		RECC333B22
R35, R36, R37, R38, R39	Resistor	22M, 1/4 W, 5%		RECC226B22
R40, R41	Resistor	43k, 1/4 W, 5%		RECC433B22

REF DESIG	PART	DESCRIPTION	MANUFACTURER AND PART NUMBER	EBERLINE PART NUMBER
S1	Switch		Eberline 10652-B09	SWRO37
	Transformer Assembly	High Voltage	Eberline 10931-00	YP10931000
3. Audio Divider Board				
A5	Integrated Circuit	CMOS Binary Counter/Divider	402OB	ICCMA4020B
C20	Capacitor	Fixed, 4.7 μF, 10 V, 10%	CS13 Case B	CPTA475P3F
C21	Capacitor	100 pF, 1 kV, 20%	CRL DD101	CPCE101P3U
Q20, Q21	Transistor		2N4124	TRSN2N4124
R25	Resistor	Variable	Bourns 3299W-1-103	PTCE103B33
R50	Resistor	Fixed, 20k, 1/4 W, 10%		RECC203B22
R51	Resistor	Fixed, 2.7k, 1/4 W, 10%		RECC272B22
R52, R54	Resistor	Fixed, 10k, 1/4 W, 10%		RECC103B22
R53	Resistor	Fixed, 8.2k, 1/4 W, 10%		RECC822B22
R55	Resistor	Fixed, 62k, 1/4 W, 10%		RECC623B22
4. Detector				
	Photomultiplier Tube		EMI 9524 C or equivalent	TUPM4
	Crystal	Sodium, Iodide, (Thallium Activated)	Harshaw 4D4	CYNI4
	Photomultiplier Tube Socket			ZP10438004
	Dynode Resistors	8.2M, 1/4 W, 5%		RECC825B22
	Resistors	10M, 1/4 W, 5%		RECC106B22
	Resistors	15M, 1/4 W, 5%		RECC156B22
	GAIN ADJ Potentiometer	7.5M, 30%		PTCC755B02



NOTES:
1. ALL CAPACITOR VALUES IN MICROFARADS EXCEPT AS NOTED.
2. ALL RESISTOR VALUES IN OHMS. K=10^3 MEGO=10^6.
3. A2 IS TYPE MC 717P.
4. A1 AND A4 ARE TYPE CA3046.

Figure 6-1A. General Schematic, Model PRM-7



All Resistor Values in Megohms

Figure 6-1B. Detector Schematic, Model PRM-7

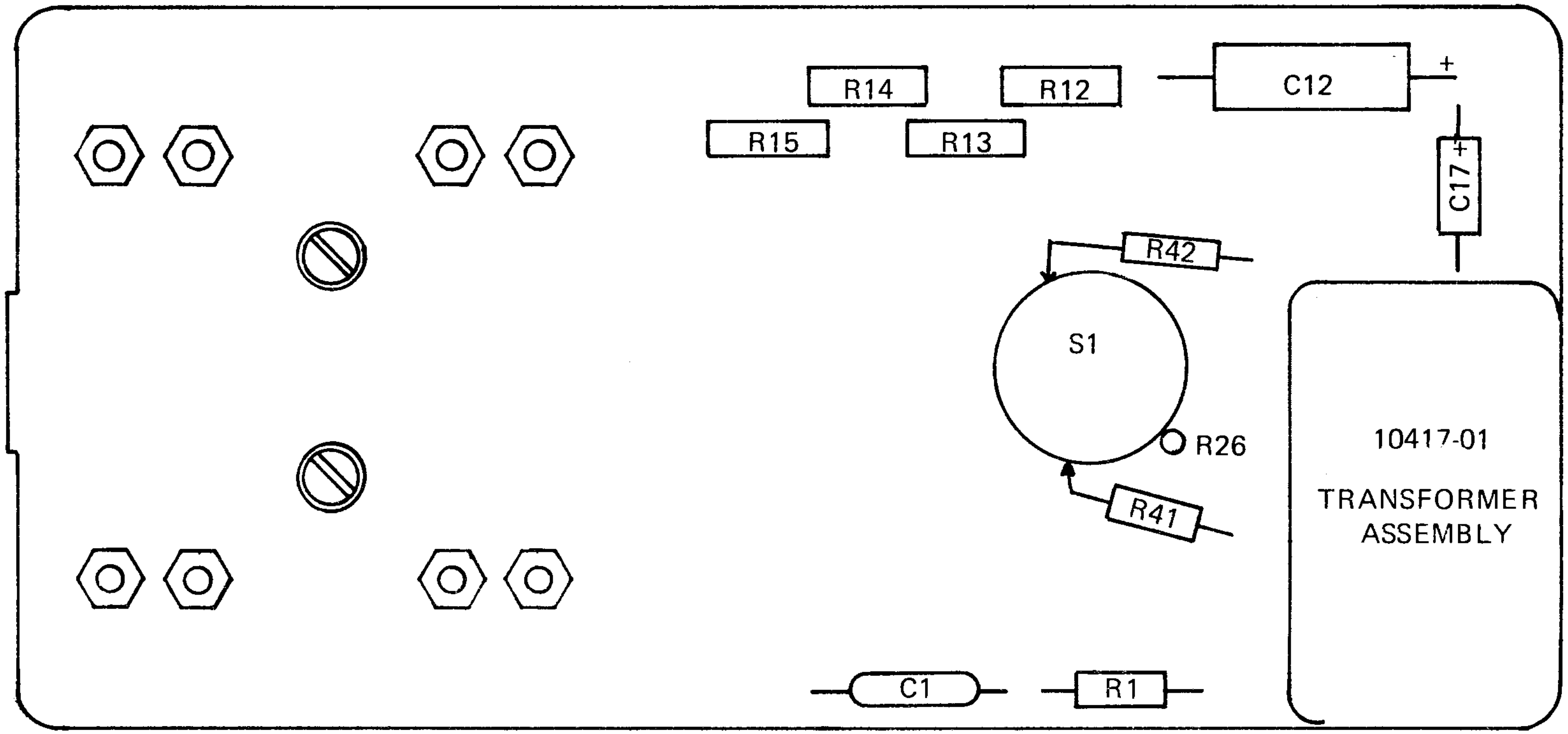


Figure 6-2. Component layout, Electronics Board (Sheet 1)

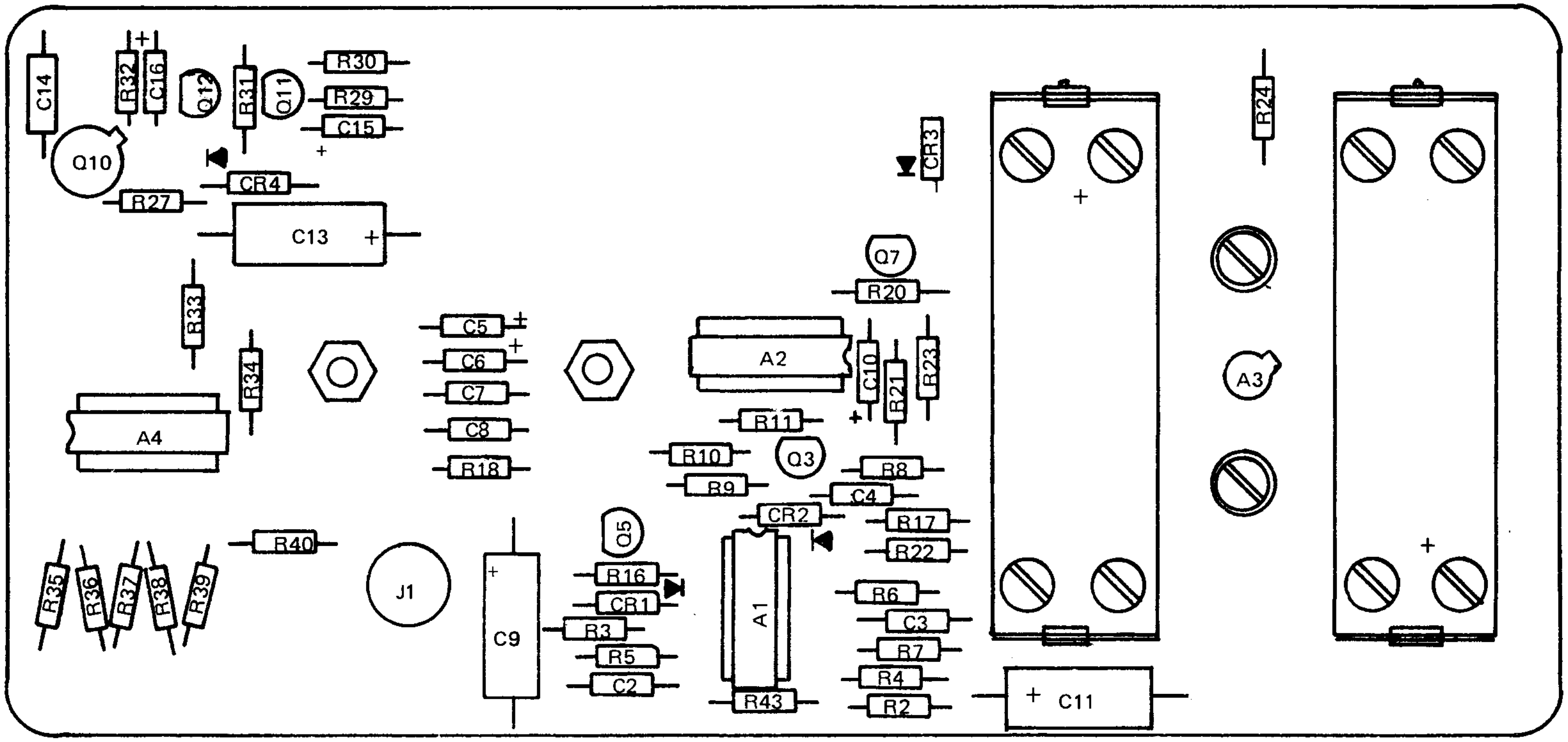


Figure 6-2. Component Layout, Electronics Board, Sheet 2

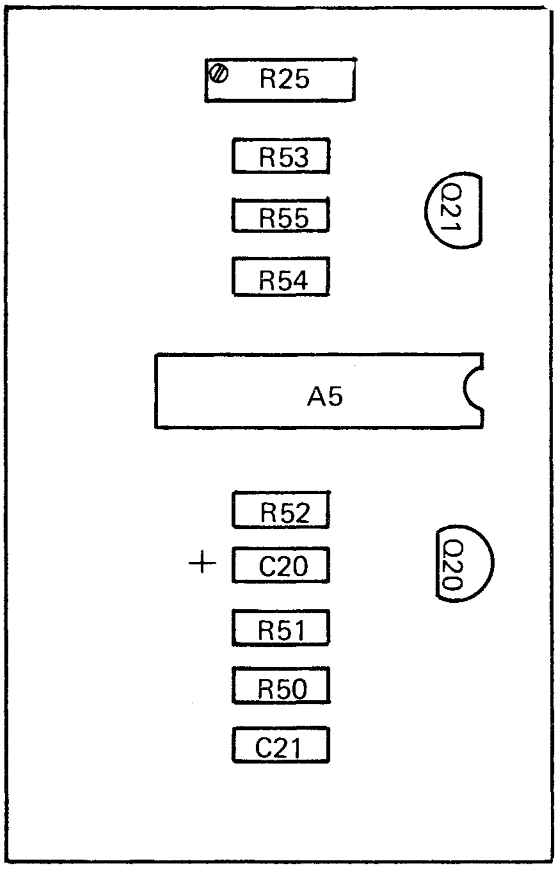


Figure 6-3. Component Layout, Auxillary Board